WOCE

World Ocean Circulation Experiment

NEWSLETTER

Number 6 October 1988

FEATURES

NEWS FROM THE WOCE-IPO

During the past year most of the effort of the SSG and IPO has been directed toward the preparation and publication of the WOCE Implementation Plan and planning the first International WOCE Scientific Conference to be held 28 November to 2 December 1988 at UNESCO Headquarters in Paris. The Implementation Plan was the principal item of discussion of the SSG meetings held 17 to 20 November 1987 in Washington and 11 to 13 April 1988 at the IPO. A full working draft was finally distributed for comment in early June 1988 and the final version sent to the WMO for publication in the WCRP series in late July. At this time advance copies were also distributed by the IPO to the international WOCE community and by the IOC to official intergovernmental contacts.

The Implementation Plan is being published in two volumes. The first gives an overview of the objectives of WOCE and the strategy for meeting them, details of the implementation of the experimental elements of WOCE, data management, the modelling programme and extensive detailed tables listing the resources needed for the Experiment in terms of hydrographic sections, mooring arrays, floats, drifters, etc. The second volume contains the detailed description of the three Core Projects which form the heart of WOCE. It provides the scientific rationale that has led to the field programme for WOCE and provides details of the experimental elements that make up the field programme as well as how, taken together, they constitute a coherent programme that meets the overall objectives of the Core Projects and of WOCE itself.

The first volume of the Implementation Plan is highly referenced to the second, especially concerning the detailed resources needed for the Experiment. The second volume reiterates some of the material in the first volume and may he considered as a relatively self-contained description of WOCE and its Core Projects. Although both volumes may be of use to some readers without reference to the other, a full understanding of the scope of WOCE and the complexity of its implementation can only be obtained from the material contained in the two volumes.

Most of the material contained in the Implementation Plan has evolved from the Core Project Planning Meetings held during 1986, the reports of which have been published. The ideas expressed at these meetings has been refined by the Core Project Working Groups under the direction of the SSG.

Published by: WOCE International Project Office at Natural Environment Research Council, Institute of Oceanographic Sciences, Brook Road, Wormley, Godalming, Surrey, UK.
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Perhaps the greatest change since the Planning Meetings have taken place is the evolution of Core Project 3. Considerations as how to best resolve certain processes of particular importance to WOCE and to obtain for a large region of the ocean a more detailed data set for modellers than will be available for Core Project 1, have led to the description of an experiment in the Atlantic Ocean. Enhanced measurements will be obtained on various scales of interest. Principal among these are float and drifter measurements over the complete Atlantic, control volume experiments in the North Atlantic, the Deep Basin Experiment in the Brazil Basin, enhanced measurements over depth in the tropics, and various process studies to take place in the North Atlantic, usually in conjunction with the control volume experiments. A meeting of some 40 to 50 scientists interested in participating in Core Project 3 was held 27 to 29 April 1988 in Miami. As a result of the meeting changes were made to the final drafts of the Implementation Plan to reflect the refinements to the scientific programme that were agreed.

The Implementation Plan will be the principal document for discussion at the International WOCE Scientific Conference. The principal objectives of the Conference, which is being organized by a committee chaired by the Chairman of the SSG, Professor Carl Wunsch, were stated in an announcement for the Conference released by the parent bodies of WOCE (ICSU, SCOR, WMO and IOC) early this year. These objectives are to review and explain the scientific purposes of WOCE; to outline the plan for the implementation of WOCE; to identify means by which countries can contribute to WOCE; to identify major resource commitments as well as gaps and how the latter can be overcome; to review additional requirements for WOCE, including data submission and distribution, access to ports and scientific data from Exclusive Economic Zones; and examine institutional arrangements for WOCE.

The programme for the Conference, which is in the final stage of planning, is included elsewhere in this Newsletter.

The Conference will provide WOCE planners with the first opportunity to determine how much of the WOCE field programme, which has been under development for several years and now is formulated in detail in the Implementation Plan, will be carried out by national programmes. Indeed, preparations for the Conference have become a landmark in the development of these national WOCE programmes in a number of countries as the interests of scientists, availability of resources and national concerns and strengths are assessed.

Although the Conference will be a major step in the development of a truly international WOCE programme, it will only be one such step. Consideration is already being given to the mechanisms by which the SSG, its Working Groups and Planning Committees and the IPO, in co-operation with funding agencies and national, international and intergovernmental bodies, will re-assess the WOCE field programme and seek consensus on priorities in the light of the available resources. Co-ordination in space and time of the large number of experimental components listed in the Implementation Plan in a way to best meet WOCE goals presents a major challenge, even if the resources required are available. Consideration of these matters will form a major part of the agenda of the SSG meetings to be held just before and after the Conference.

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A Note from the Editor

No, the WOCE Newsletter is not an annual publication. It has been dormant for the past year due to a number of pressures but it is hoped that it will be published more regularly in the New Year, starting with an issue following shortly after the WOCE Conference. Our initial aim was that the Newsletter would be used to publish reports from the IPO and that colleagues would use it as a means of highlighting scientific achievements of interest to WOCE and to report progress of scientific programmes and working groups and in experiment design and modelling effort.

The editor would be pleased to receive articles, long or short, scientifically detailed or just newsworthy tit-bits, which could he included in forthcoming issues. As the saying goes, ‘all contributions would be gratefully received’.

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ERRATA

The editor wishes to apologise for an error which occurred in the article entitled ‘Drifting Buoy Data for Marine Research’ by J.R. Keeley and S.L. Patterson published in the last issue of the Newsletter. The second sentence should read “with subsequent improvements in buoy system capabilities, buoys are now providing a cost-effective means of obtaining long-term, in-situ measurements of environmental parameters from vast remote ocean areas.”

PROGRESS IN THE US WOCE OCEAN COMMUNITY MODELLING EFFORT

1. Introduction

The first of the two stated goals of WOCE is "To develop models useful for predicting climate change and to collect the data necessary to test them". The Community Modelling Effort (CME) has been initiated in order to accelerate ocean model development in support of this goal. The CME is a multi-year, multi-institutional endeavour, focusing on basin-scale, eddy-resolved modelling of the combined wind and thermohaline driven circulation. This report gives an overview of the concept of a community effort, and describes a first calculation in what is planned to be an extended series.

The first experiment in this effort, a simulation of the North Atlantic, is currently underway at NCAR. Innovations over previous eddy resolving ocean circulation experiments include: the first use of realistic basin geometry and bottom topography, the inclusion of salinity as well as temperature as a state variable, and the use of realistic spatially and temporally varying surface wind and thermohaline forcing. This experiment (and perhaps the first of several in the CME) will be primarily a benchmark calculation. It is designed to evaluate the ability of existing ocean general circulation models to meet WOCE objectives, and to identify which aspects of the models and/or boundary conditions are most in need of improvement. 'The analysis of this first experiment will concentrate on comparisons of the basic hydrographic structure, climatic properties, and a few key time series with available historical data sets.

In addition to model development, it is hoped that the CME will enhance communication within the ocean modelling community, and between modellers and observationalists. Members of the ocean modelling community were solicited for input into the design of the first experiment at several meetings during 1986, and through personal communications. An ad hoc planning group has formed, with members representing universities and research institutions in the US, Canada, France, Germany, and the UK. This group will be responsible for organizing input from the larger oceanographic community, making final decisions in the design of the experiments, and securing computational resources for future experiments in the series. Parallel modelling efforts are planned or are underway in the UK, France, and Germany, and we expect there to be close communication between the active groups. The computational resources required for calculations of this type are large, exceeding 1000 hours of CPU time per experiment on existing supercomputers. In addition, the data sets produced will he larger than any individual, or even single modelling group, can thoroughly analyze. Working in the community context will allow us to take on this large problem by pooling computational resources, and by directing a broad range of expertise and interest towards the analysis of the results.

In order for this effort to succeed there must be a vigorous interaction between the CME and other types of modelling programmes. Significant deficiencies or poorly understood aspects of the CME calculations should inspire less costly process studies of the phenomena in question, and these in turn should suggest improvements in the models used in the CME calculations. Models of the size and cost of the CME calculation described below simply cannot he run for enough cases, and over a broad enough range of parameter space, to answer many of the questions which we will face in the course of developing models for WOCE. It is essential that the types of process studies of isolated phenomena, familiar to the modelling community, continue to be pursued. On the other hand experience gained from these basin-scale simulations will be essential in approaching the global modelling problem which is the central focus of WOCE.

2. The First Experiment

The first experiment of the CME was chosen to be a simulation of the North Atlantic basin, with a focus on the subtropical and subpolar gyres. The North Atlantic was chosen because it is the best observed basin of the world ocean, and because of its relatively small size. The primitive equation model developed at GFDL (Bryan, 1969; Semtner, 1974; Cox, 1984) was chosen as it is the most general and portable model currently available. Future experiments may use other codings of the same model, or even new model formulations or physics. Both eddy and non-eddy-resolving versions of the model are being used. The horizontal resolution is 1° latitude by 1.2° longitude in the coarse resolution version, and 1/3° by 0.4° in the fine resolution version. The main calculation is planned to be a 25 year integration of the fine resolution model which will require approximately 1500 hours of (single processor) CPU time on a CRAY X/MP-48 to complete. The coarse resolution model is being used to make preliminary tests of surface forcing functions, lateral boundary conditions, and sub-grid scale parameterization schemes. Comparisons of the solution of the coarse and fine resolution versions of the model forced with the same surface conditions will also allow us to make a first estimate of the resolution dependence of the solution. As initially configured both coarse and fine resolution versions used 20 levels in the vertical, 12 of them above 1000 m depth. The domain extends from 15°S to 65°N, and includes the

Caribbean/Gulf of Mexico, but not the Mediterranean. Bottom topography has been included as realistically as possible at the resolution used. A summary of the model physics and parameters is given in the Table.

North Atlantic Basin Model

Outline of Initial Configuration

1. Model Configuration

a) Domain
   i. Position of southern boundary: 15°S
   ii. Position of northern boundary: 65°N
   iii. Adjacent seas: Gulf of Mexico, Caribbean

b) Topography: Derived from NGDC 10' data set, minimal smoothing

c) Islands: Cuba, Hispanola (single island in low resolution case)

d) Horizontal resolution: low resolution 1° x 1.2°, high resolution 1/3° x 0.4°

c) Vertical resolution: 20 levels, 35 m to 950 m or 30 levels, 35 m to 250 m

2. **Model Physics**

a) Horizontal mixing:
   Low resolution-Laplacian/isopycnal
   High resolution-Biharmonic/cartesian

b) Vertical mixing: Constant coefficient (plus isopycnal rotation - low resolution only

c) Mixed layer: Kraus-Turner type

3. **Surface Forcing**

a) Wind stress; Hellerman monthly mean

b) Temperature: Linear Haney type flux formulation with seasonal variation

c) Salinity: Resorting to Levitus Climatology.

4. Open Boundaries

a) Southern boundary: closed wall with 5° wide sponge layer

b) Northern boundary: as above.

Seasonally varying wind and thermohaline forcing are being used. Several alternative wind stress data sets are currently being examined for use in the fine resolution calculation. The monthly climatology of Hellerman and Rosenstein (1983) is currently being used. The formulations of the surface boundary conditions for temperature and salinity are also still undergoing experimentation. Haney (1971) type linear surface flux relations, with various choices for the "apparent atmospheric temperature" have been used thus far. The open boundaries at the northern and southern ends of the domain and the effects of the Mediterranean are being treated with "sponge layers" in which temperature and salinity are restored towards their observed values.

During the first year that the effort has been underway, we have been occupied largely with the technical details of assembling data sets for the boundary and initial conditions, implementing the model on the NCAR computing system and adjusting parameters and boundary conditions in order to numerically stabilize the integration. We have now carried out several experiments of 25 to 50 years duration with the coarse resolution model, and have run the fine resolution model for approximately three years, though many adjustments were made during this short integration. It is only very recently that we have begun to address issues of improving the representativeness of the solution. One deficiency of the model (both in the coarse and fine resolution versions) is separation of the Gulf Stream from the coast too far to the north of Cape Hatteras (Figure 1). This problem has plagued virtually all previous attempts at modelling western boundary currents with the primitive equation model. Due to the consequences of this error on the downstream distributions of properties, and the importance of the Stream in the integral behaviour of the model, we feel it is particularly important to do all that we can to improve this aspect of the solution. Possible contributions to this problem include errors in the specified wind stress, problems associated with discretization of topography, unrealistic model physics (particularly lateral dissipation and boundary conditions), and in the fine resolution version, too smooth an initial condition. As mentioned above, we are testing several alternate wind data sets, based on climatological surface observations and operational atmospheric forecast models. We are also experimenting with the use of higher vertical resolution in order to improve the representation of bottom topography. It is likely that the final version of the model will have 30 levels. Obviously we cannot begin to address all of these problems in a single calculation. This point emphasizes the need to carry the CME on as a sequence of experiments, and the need for parallel, process oriented modelling efforts directed at specific issues of this kind.

Even if we are not able to overcome the separation problem in this first calculation, there will be many interesting features of the solution to analyze. Some of these have become apparent after only a few years of integration. The Loop Current of the Gulf of Mexico has shed rings of large amplitude, and the Gulf Stream eastward of Cape Hatteras is developing vigorous meanders and is shedding rings (Figures 1 and 2). There is a vigorous flow through the Romanche Trench between the Western and Eastern basins of the deep equatorial region and an associated transfer of water mass properties (Figure 3). Waves have begun to amplify and steepen on the North Equatorial Current. Idealized passive tracers with various input functions have been included in some of the early experiments, and these give tantalizing images of the transport and pathways of water masses in the basin. With these and numerous other aspects of the solution we can ask how they compare with observations, how they interact with the remainder of the circulation, and what they imply in terms of observational strategies for WOCE. As of late January 1988, we are very

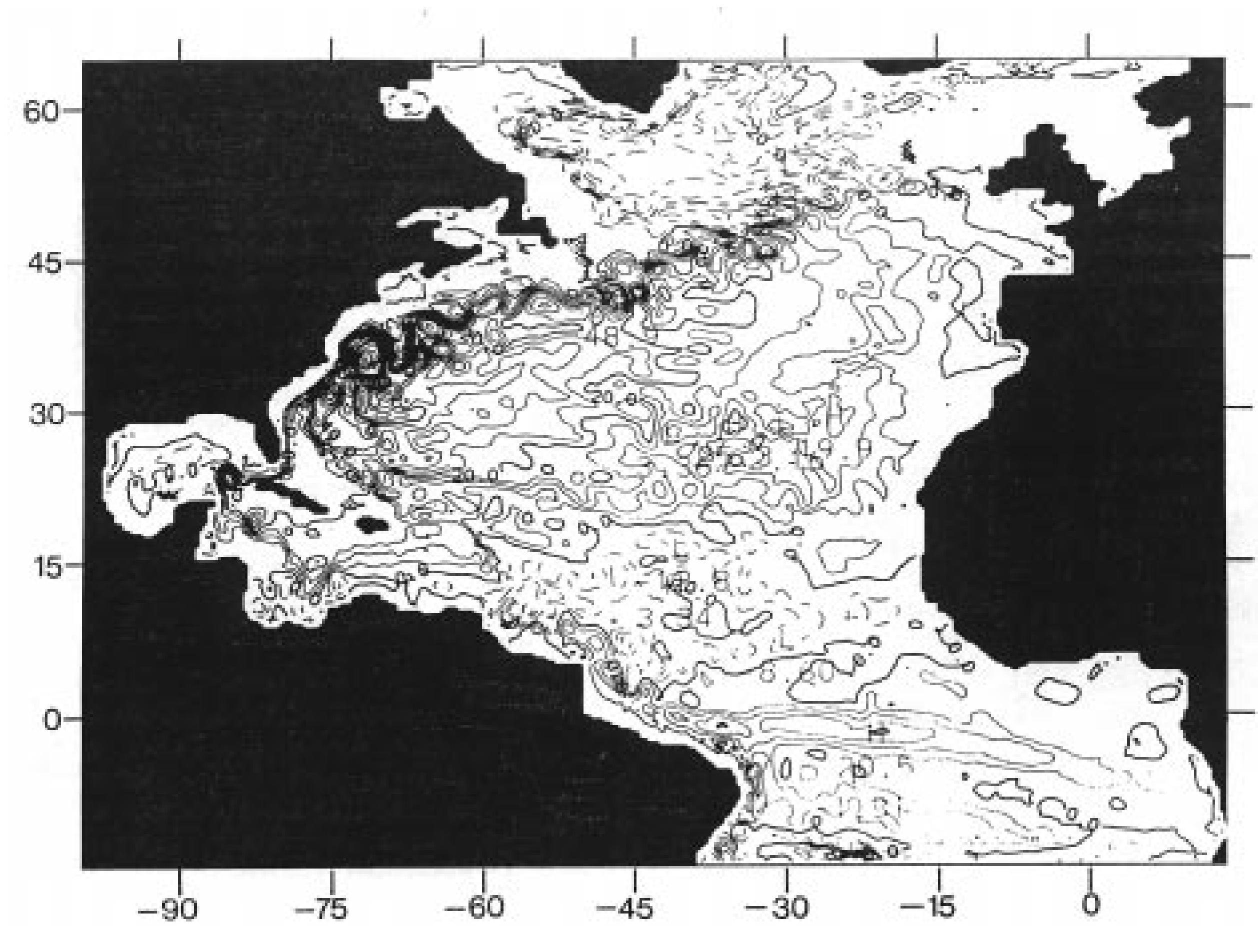

Figure 1 Barotropic stream function for the fine resolution model on day 353 of the third year. Contour interval is 5×10^6 m s^{-1}.

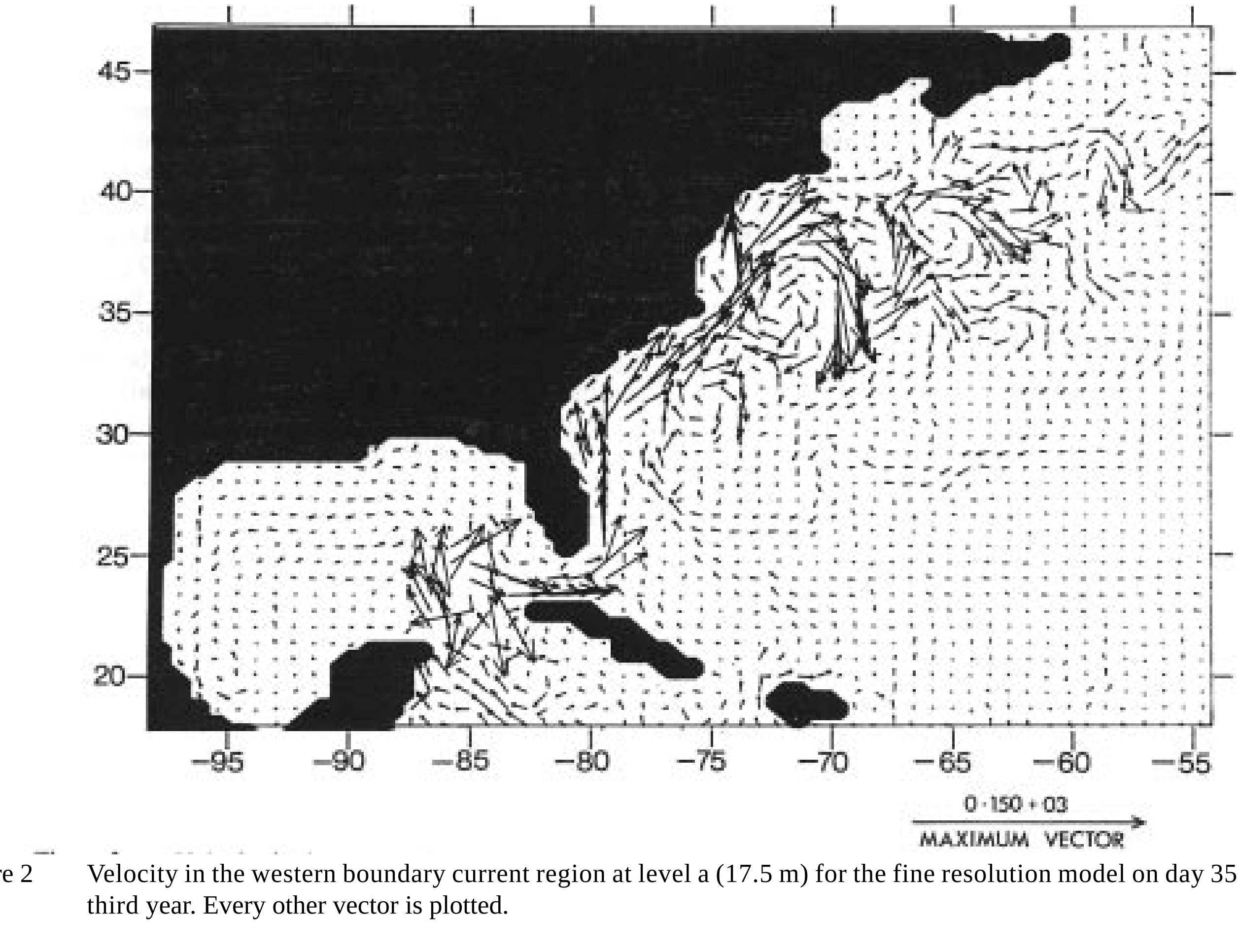

Figure 2 Velocity in the western boundary current region at level a (17.5 m) for the fine resolution model on day 353 of the third year. Every other vector is plotted.

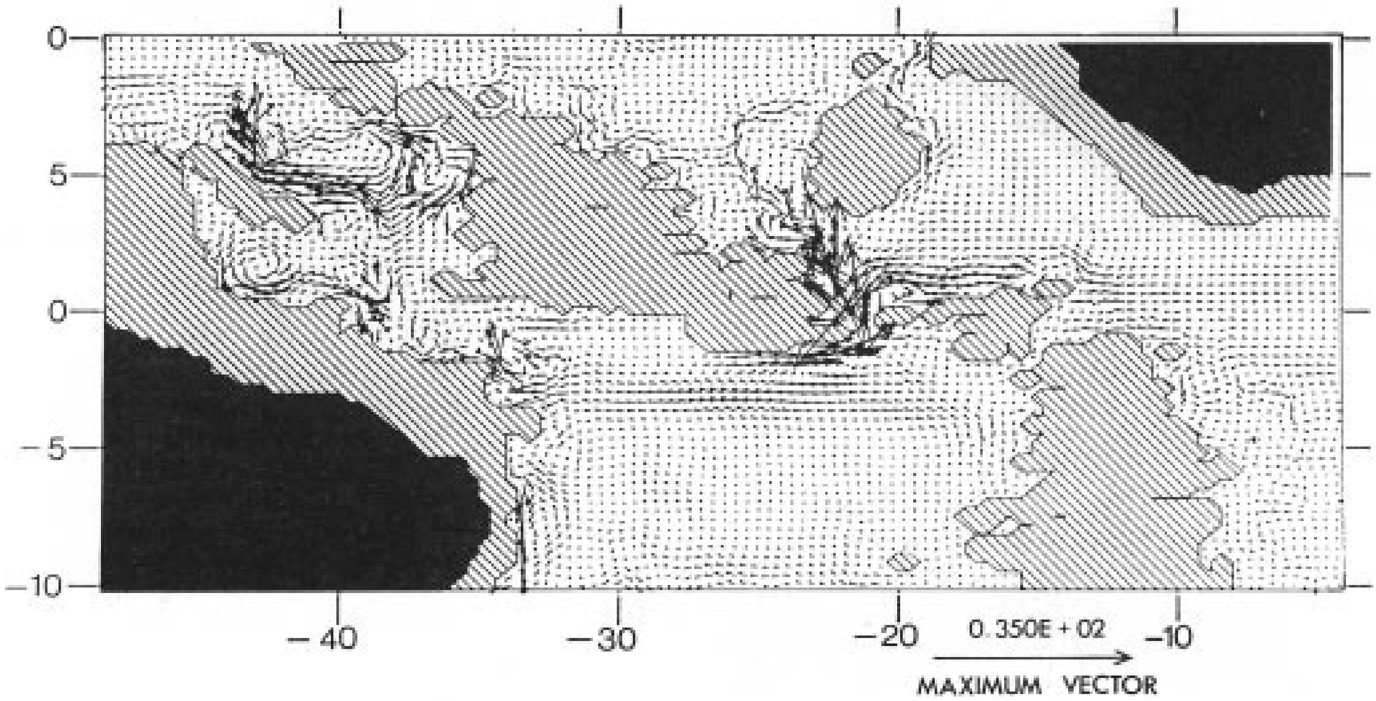

Figure 3 Velocity in the Equatorial region at level 24 (3857 m) for the fine resolution model on day 353 of the third year.

close to beginning the production run of the fine resolution model. This is expected to take between 9 months and a year to complete (we can expect to have the use of a processor for no more than about 6 hours per day in the NCAR computing environment).

A major practical problem which we have yet to settle is the sampling and archiving of the final high resolution calculation. A single realization of the primary prognostic quantities of the fine resolution model requires approximately 8.5 million words of mass storage. Assuming a sampling frequency of once per 3 days, an archive of 5 years length will require the equivalent mass storage of more than 250 (6250 bpi) tapes. Obviously this raw data set must be reduced to a manageable subset or averaged in some way to make extensive analysis possible. The types of data sets produced depends primarily on the interest and participation of the community. The computing resources acquired for this experiment do not include time for extensive post-processing or analysis of the solutions. In order for the maximum utility of this experiment and future ones to he realized, individuals must take the initiative to acquire the necessary resources and take on the analyses.

3. Management of the Extended Effort

In addition to the practical advantages of pooling of computing resources and manpower associated with working in the community context, there are several benefits to coordinating an extended model development process. A carefully planned sequence of experiments, in which the differences introduced to the models from experiment to experiment are carefully chosen, will allow us to quantitatively estimate improvements in model performance. It is exceedingly difficult to do this when there are more than a few differences between models, as previous “model intercomparison studies” have shown. It is expected that subsequent experiments in the sequence will be directed by modelling groups in addition to ours. In this way a larger number of people will be exposed to the project, and it is hoped that a broad group of individuals will become involved in, and make contributions to, ocean modelling. As mentioned above, in order for the full utility of the experiments to be realized, a broad cross-section of the oceanographic community must become involved in the analysis of the results. The final data set, planned to be a

5 year archive of all major prognostic quantities and perhaps a few primary analyses, e.g., long term statistics, will be made available to interested investigators. At this time no formal mechanism has been established for the distribution of this data. We are currently exploring various means of making access to the data as simple and efficient as possible. In the mean time we plan to make a hard copy “atlas” of results available. During the course of the integration we hope to make several more reports of this kind, informing the community of our progress and early indications of the successes and failures of the simulation.

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THE WOCE HYDROGRAPHIC PROGRAMME: A STATUS REPORT

1. Introduction

The primary scientific objective of the World Ocean Circulation Experiment (WOCE) is to understand the general circulation of the global ocean well enough to be able to model its present state and predict its evolution in relation to long-term changes in the climate. The large-scale circulation includes ocean currents which are directly observable (for example, by current meters or ship drift), and processes of watermass formation, modification and movement which are more indirectly studied. All are important to WOCE, and it is of value to determine the ‘mean’ circulation, and also its variability on annual to decadal time and appropriate space scales.

The field programme to meet these objectives will be both intensive, with repeated sampling in certain critical regions, and extensive, with a global coverage. The in situ programmes will take advantage of the opportunity to obtain multi-year, global observations from the next generation of ocean observing satellites. There are a number of ‘tools’ that will be used in WOCE to study ocean circulation, including satellites, drifters, floats, moored buoys and tide gauges. But perhaps the most venerable involves the measurement of the distributions of density, temperature, salinity, and chemical tracers. From this, one infers the distribution and sources of water masses and their flow velocities and patterns. Thus an important component will be a major effort to improve our knowledge of these distributions through the WOCE Hydrographic Programme (WHP). The primary goal of the WHP is to obtain high-accuracy global hydrographic and geochemical tracer measurements.

Although the details remain yet to be determined, estimates have been made that some ten years of ship time will he needed over the Intensive Observation Period beginning in 1990, not including repeat hydrography. No single oceanographic institution or nation has the resources to provide either the ships or measurement capability to undertake this programme; thus, the WHP will be international with different countries, laboratories, and research vessels involved. It will be important to ensure uniformity of measurement technique and intercalibration. One approach may be to use a small number of dedicated ships manned, in part, by specially trained teams of skilled and experienced oceanographers.

The overall scope of the WHP has been developed in a series of national and international planning meetings over the past two years. This plan is still evolving. In many cases, especially for the South Pacific and Indian Oceans, the sections will provide data where none now exists. In other cases, the sections will repeat those taken in the past so that decadal and longer time-scale changes in the circulation and tracers can be detected. Some of the sections will be repeated seasonally in regions where the general circulation is known to have strong variability. In addition, certain sites will be chosen for temporal sampling over a long period of time to extend the time series of observations beyond the five-year intensive period of WOCE. These will be important for establishing the long-term climatic change in the ocean. The primary practical objective of WOCE is to provide the scientific background for an observing system for long-term measurement of the large-scale circulation of the ocean in the future.

Except for a concerted effort to cover a single ocean basin in a short period of time (e.g., the Atlantic hydrographic survey during the International Geophysical Year(s) in the late 50s), our observations of the global circulation have been accumulated over many decades with a wide variety in the accuracy of the hydrographic measurements. New technologies and the utilization of new tracers, some of which are transient in their input to the ocean (due to man's influence) have given us new tools and an impetus to collect a global 'five-year snapshot' of the state of the ocean. This will, on the one hand, permit oceanographers to compare the present ocean with that of the past, and will also provide an accurate global baseline for detection of future changes in the ocean.

The International Scientific Steering Group (SSG) for WOCE has appointed a planning committee for the WHP. The members of the committee are presently T. Joyce, Chairman (US), M. Fieux (France), M. Fukasawa (Japan), P. Saunders (UK), R. Weiss (US) and W. Zenk (FRG). The committee receives its input from the three scientific planning working groups: Core Project 1 (Global Description), Core Project 2 (Southern Ocean), and Core Project 3 (Gyre Dynamics). It will advise the SSG on the design and implementation of the WHP, measurement accuracies, facilities necessary, ship requirements, protocols, and WHP management. The planning committee had its first meetings in Wormley, 27-28 April 1987, Woods Hole, 13-14 October 1987 and Kiel, 7-8 April 1988. Prior to these meetings, a gathering of US oceanographers was held in La Jolla and a report prepared.(1) This report will summarize the main recommendations of these three meetings.

2. Recommendations

2.1 Sampling Accuracies

Sampling accuracies are presented separately for CTD/O_2 sensors and measurements from individual water samples.

<u>CTD-Sensors</u>: there seems to be enough evidence to advocate the use of dual, or even multiple, sensors on CTDs. When implemented, any abrupt change in sensor behavior can easily be detected, while continuing the measurements and thus saving ship-time. This important improvement in reliability would have a very positive effect on the ship-time needed for deep casts, since DSRT thermometers are used only for checking sensor performance and add up to 2 hours of station time for accumulating 'soaking time'. Although work was reported on the development of new conductivity cells (Seabird, NBIS, Salzgitter Elektronik), it was felt that additional attention should also be given to the temperature (stability) and the pressure sensors (hysteresis). To underline the need for uniform data quality during WOCE, there is a need to begin immediately with instrument selection and performance monitoring. This led to the idea of an <u>in situ</u> measurement working group within the WHP. Special care should be given to the development of an efficient O_2-sensor, with similar time response characteristics as the other sensors.

The following <u>requirements</u> for the individual <u>CTD-sensors</u> were confirmed:

T: accuracy of 0.002°C, precision 0.0005°C.

S: accuracy of 0.002 PSU, depending on frequency and technique of calibration, precision 0.001 PSU, depending on processing techniques. It was felt that although conductivity was measured, data analyses require knowledge of useful limitations expressed as salinity.

P: accuracy 3 dbar with careful laboratory calibration, precision 1 dbar, dependent on processing. Difficulties in CTD-salinity data processing occasionally attributed to conductivity sensor problems or shortcomings in processing, actually may be due to difficulties in accounting for pressure sensor limitations.

O_2: accuracy 1-1.5%, same for precision. As yet there is a lack of adequate sensors.

In general it was agreed that a safe way to detect drift or jumps in sensor performance would be by using dual and exchangeable sensors.

For <u>water samples</u> the following <u>requirements</u> were accepted:

T: DSRT are available with 0.004-0.005°C accuracy and 0.002°C precision for expanded scale instruments. Reliable multiple CTD-sensors have the potential to eliminate the standard use of DSRTs. Digital DSRTs do not require long soaking times and have the potential to serve as a means for calibration and performance checks. Their development and in particular their long-term stability will be closely monitored.

S: accuracy 0.002 PSU is possible with Autosal salinometers and great care taken to monitor Standard Sea Water. Accuracy with respect to one particular batch of Standard Sea Water can be achieved at 0.001 PSU. Precision of Autosal is better than 0.001 PSU, but great care and experience is needed to achieve these limits on a routine basis as required for WOCE. Laboratories with temperature stability of 1°C are necessary for proper Autosal performance.

Keeping constant temperatures in the room where salinities were determined would greatly increase their quality. Also, room temperatures should be noted for later interpretation, if queries in salinities occur. With respect to IAPSO Standard Sea Water, its frequent use was again endorsed. It was also noted that changes in the Standard Sea Water occur. To avoid these, if possible, the use of the most recent batches was recommended, besides using the ampoules in an interleaving fashion to have a consistency check within a batch or batches.

O_2: accuracy < 1%. Some laboratories achieve 0.5%, which is desirable for deep sea work and hence required for WOCE, and 0.1% precision, with improvements due to developments in 'new' end-point detection techniques. Development of these techniques and subsequent adoption was strongly recommended.

SiO_3: accuracy approximately 3% and full-scale precision. Strong opinion exists that laboratory temperature fluctuations cause significant errors, as 1°C laboratory fluctuation yields approximately 1% change in SiO_3.

NO_3: approximately 1% accuracy and precision full scale. This standard is probably appropriate to WHP.

PO_4: approximately 1-2% accuracy and precision full scale. There was a brief discussion of nutrient standardization, with a general recommendation that it may be worthwhile to examine standards for nutrients.

^3H: 1% accuracy and 0.5% precision with a detection limit of 0.05 tritium unit (TU) in the Northern hemisphere, upper ocean and 0.005 TU elsewhere.

δ^3He: 1.5 per mille in accuracy/precision in isotopic ratio; absolute total He of 0.5% with less stringent requirements for use as a tracer (e.g., He plume near EPR).

CFCs: accuracy/precision at approximately 1%, blanks at 0.005 pM with best technique. Investigation of chlorofluorocarbon collection and analysis technology appropriate to these quality levels on "mass production" basis.

$\Delta^{14}C$: per mille via beta-counting on 200-liter samples; 5-10 per mille with Accelerator Mass Spectrometer (AMS).

^{85}Kr: detection limit of 1% of surface concentration; precision of 4% decreasing to 25% for samples near the detection limit.

^{39}Ar: precision of 5% of surface value; minimum detectable amount about 5% of surface value.

^{228}Ra: 5% accuracy/precision.

$\delta^{18}O$: may be used in high latitudes; these should be measured with accuracies of 0.02 per mille.

2.2 Sampling Summary

Station sampling will be full water column for all measurements. The CTD/O_2 will provide a continuous profile from the surface to within 10 m of the ocean bottom (in good weather over mild topography). Small volume (≤510 liter) water sampling will be carried out on each cast. A minimum number of samples for a deep cast will be 24; the optimum number of 36 samples will provide better resolution near the surface layer as well as in the deep water. The basic horizontal resolution on each section will be 60 nm in the interior of the basins with 30 nm spacing across strong currents (e.g., Polar Front, Gulf Stream, Equatorial jets) with high resolution near ocean boundaries and large-scale topographic features. Some sentiment was expressed in the US meeting for 30 nm spacing in the interior to prevent aliasing by eddies. This would increase total station time for the WHP; this issue of interior "resolution" for the density field could be resolved with XCTDs or "fast fish" profiles in between regular stations. Large volume sampling with Gerard barrels will be carried out with a horizontal resolution of 300 rim with 9-18 samples per cast. Geochemical sampling from both large and small volume samples will vary from region to region. For example, stable isotopes of hydrogen and oxygen have been recommended for sampling in high latitudes (e.g., Southern Ocean). The specific transects to be occupied and geochemical sampling are still being discussed and will be firmed up in a series of future planning meetings for each ocean basin.[2]

Personnel requirements will vary depending on the operating mode of each technical group. Assuming a model of three watch groups, requirements are nine people to stand watch, two specialists each for nutrients and CFCs, one specialist each for electronics, data processing, oxygen, salinity, underway acoustic-Doppler velocity profiling, and large volume sampling. In addition, we estimate that two people will carry out CO_2 analyses for the Joint Global Ocean Flux Study (JGOFS). With the addition of a chief scientist, this totals 23 individuals. Additional personnel are expected for ancillary measurements, float and drifter deployments, foreign observers, and students.

3. Ship Requirements

Approximately two-thirds of the long sections proposed can be done in 30 days or less; some, however, will be in excess of 75 days (South Pacific). The scientific party, including observers and ancillary programmes will number 25-30. The research vessels must be equipped with acoustic-Doppler logs (150 kHz) and GPS navigation. For high latitude work, especially in the Southern Ocean, ice strengthening will be required. Specialized, temperature-controlled labs for water sample analyses will require space equivalent to four 20 ft vans. A semi-enclosed wet lab/rosette room will be required as well as some means of transport for the water sampler to and from the deck. Methods discussed included an overhead cable or a deck-mounted rail. Because of the heavy demands on water sampling with the CTD package, there is a need for a dedicated winch and conducting cable as well as an A-frame or similar device for getting the package in and out of the water and a means for moving the package around safely on deck between casts. Also discussed was the desirability of roll and heave compensation on the vessel in order to extend the weather window. Large volume Gerard bottles will be deployed at selected stations using a trawl winch. Present methods for this sampling (mechanical messenger or acoustic trigger) do not require the trawl wire to have a conducting core. It should, however, be able to reach the ocean bottom. The ship should be "clean" with regard to ^{14}C and tritium and there should be separate air system controls for labs and living spaces. No computers will be required as ship-supplied equipment but environmentally adequate space is required for a centralized computer with some distributed work stations/terminals. It is desirable that some forms of data be exchanged between the ship and shorebased labs. This will likely occur in bursts, rather than continuously at low data rates. Commercial communication networks, such as INMARSAT, should be adequate.

4. Future Items for WHP

Other items were discussed that are not sufficiently developed to detail at this time. These can be generally grouped into the categories of facilities, WHP management, and WHP working groups.

4.1 Facilities

It must be recognized that the WHP is an international programme and that facilities will need to be shared and coordinated on an international basis. In many instances, facilities now exist to carry out the types of measurements required. Seagoing operational groups and shorebased laboratories and calibration facilities are now capable of doing work to meet the standards listed above; they need to be incremented so as to meet the volume of sea time and analyses envisaged in the WHP, rather than to establish a new, international WHP organization or new national groups. In one instance, it has been recognized that a new facility in the US for analysis of small volume ^{14}C samples will be required.

4.2 WHP Management

International coordination of the WHP programme will require not only continued scientific planning but also some day to day activity which will need to be carried out on two levels: (1) an international resource council to coordinate funding for WHP activities including the coordination of large ship schedules; and (2) a project office to coordinate the activities of the various operational groups and laboratories once the overall sampling plan has been established. The project office would be responsible for solving logistical problems (e.g., getting a US water sample analysis team to coordinate with a French CTD group on a German ship), monitoring the quality of the data collected as soon as results are available, issuing cruise and data summaries on a uniform basis, and providing the conduit for all WHP data to get from the individual groups and cruises into one or more WHP data centers.

The WHP planning committee, with rotational membership and chairmen, will serve as the interface between the individual scientists and operational groups and the WOCE Scientific Steering Group. It is the task of this committee to contribute a WHP implementation plan to the overall WOCE plan.

4.3 WHP Working Groups

Four working groups have been established under the WHP planning committee to make recommendations in the following areas:

- Calibration (procedures and standards) - Saunders
- In-situ measurements - Joyce
- Standard methods and algorithms - Weiss
- Underway measurements - Zenk

In each of these groups, technical specialists will be asked initially to define problem areas and suggest methods for solution and standardization.

Further details on the WHP and other WOCE activities can be obtained from the WOCE International Planning Office, Institute of Oceanographic Sciences, Wormley, Godalming, Surrey, GU8 5UB, England, UK.

References

(1) The WOCE Hydrographic Program: report from a US workshop. US WOCE Planning Report Number 7, June, 1987.

(2) A chemical tracer strategy for WOCE. US WOCE Planning Report Number 10, 1988.

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A SUMMARY OF THE WOCE HYDROGRAPHIC PROGRAMME

Designing the WOCE Hydrographic Programme has much advanced. The components of the programme have been discussed and decided in meetings of the Core Project Working Groups and the three meetings of the WHP Planning Committee. Specifications both for the detailed field work, the methods and standards to be used and the infrastructure necessary to meet the objectives of the programme have been defined and are presented in the WOCE Implementation Plan.

The WHP field work breaks down into three main streams: the One-time Global Survey, Repeat Hydrography and Time-series Stations. Based on the long deliberations of the Core Project Working Groups, and subsequent fine-tuning in collaboration with the WHP Planning Committee and others involved in planning WOCE, a consistent global approach now exists.

Where for the One-time Global Survey a series of sections with adequate station spacing, full-depth casts for a suite of physical and chemical parameters together with CTD-profiles are the back-bone of the programme, Repeat Hydrography takes account of the time- and space-scales relevant to individual oceans or ocean areas. This implies also a greater variety of sampling criteria regarding the maximum depth of the casts or the mix of water samples, if any, to be taken with the CTD. Thus, the size of the ship-board party is somewhat different for the two components. The ocean-wide sections, that can range in ship-time from 25 to 75 days at sea, will require large research vessels with a scientific complement of more than 25. The repeat work on the other hand can vary from 2 to 3 days at sea to some 30 days, depending on the area. The scientific complement needed for this latter work will often be smaller and sometimes may be only a CTD-group on a 24 hour routine. A summary of the proposed WHP activities is given in the Table. More details can be found in the WOCE Implementation Plan.

Different in approach are the Time-series Stations which can vary from the classical hydrographic work at the Panulirus Station off Bermuda to the short repeated sections run now to the old OWS Papa, and to moored thermistor-chains covering some 1-2 km in depth. Many details have still to be decided, taking into account logistical and technical constraints in conjunction with the scientific objectives.

The four sub-groups of the WHP Planning Committee have started to address the questions of methods, standards and calibration. They are focussing on existing methods and procedures and will in due course recommend how these can be applied in a broad approach to collect and maintain a uniform, consistent high-quality data-set throughout the programme.

Specifications have been drawn up for the infrastructure needed to successfully run such a programme. A project office will oversee and co-ordinate the sea-going part, a data centre will collect and merge the data set and a special analysis centre will generate well-defined products for the WOCE community.

In the run-up to the WOCE Scientific Conference at the end of November in Paris, the WHP Planning Committee will have its 4th meeting in Paris on 20-22 October 1988, chaired by Terry Joyce from the Woods Hole Oceanographic Institution, USA.

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WOCE HYDROGRAPHIC PROGRAMME

Summary

WHP (One-time Global Survey)

OCEAN	Length (nm)		SV Stations		LV Stations		Ship Days	
Atlantic	66 353		2218		245		807	
Indian	33 253		1112		123		402	
Pacific	115 140		3872		410		1415	
Southern	14 979		500		55		184	
Global	229725	nm	7702	stations	833	stations	2808	days at sea

= 10.4 ship years based on 270 days at sea/year

WHP (Repeat Hydrography)

OCEAN	Total Length (nm)		Total Stations		Total Ship Days	
Atlantic	112 787		3152		839	
Atlantic (Core 3)	80 045		800/1076*		703	
Indian	12 079		406		91	
Pacific	294 105		9649		2189	
Southern	20 654		694		210	
Global	519 670	nm	800/14977*	stations	4032	days at sea

= 15.0 ship years based on 270 days at sea/year

*(Full WHP Stations/CTD)

THE INDIGO PROGRAMME

The INDIGO programme (Indian Geochemistry Ocean) was a French programme with participants from Canada, Taiwan, USA and Belgium. It consisted of three legs covering the western Indian Ocean from 1985 to 1987. INDIGO was aimed at evaluating the penetration of CO_2 into the western Indian Ocean and contributing to the estimation of the general circulation in the area. 103 stations were occupied, 33 of these also accommodated large volume sampling. Small volume stations consisted of 12-litre bottles at 36 levels. On board measurements of salinity, dissolved oxygen, ammonia, nitrates, phosphates, silica, total alkalinity, total dissolved inorganic carbon, CO_2 partial pressure, pH, and dissolved calcium and magnesium were achieved. Samples were also taken for laboratory analysis of boron, dissolved trace metals, surface chlorophyll, tritium and helium. In addition, syringes were attached on each bottle for onboard analyses of Freons 11 and 12. During INDIGO II and III, large volume (200 l) samples were taken at 8 levels in the upper layers. From these total dissolved carbon and rare gases were extracted on board for subsequent analysis of ^{14}C by mass spectrometry and ^{85}Kr. 30 l samples were also collected for suspended matter concentration and analysis and for oxygen consumption measurements.

The stations were selected on the basis of revisiting GEOSECS stations [11 of these stations being re-occupied 9 to 10 years after the programme] and the tracks were designed to sample the basin boundaries (see Figure). As a consequence INDIGO provided a sampling of the western Indian Ocean comparable to that of TTO in the North Atlantic and SAVE in the South Atlantic. The Atlas for INDIGO I has been published (Poisson et al., 1988). It includes discussions of the analytical techniques and calibrations, data tables of the existing values, CTD hydrographic profiles, and coloured sections of hydrographic values for nutrients and carbon species. The corresponding Atlas for INDIGO II is in press and the INDIGO III data are being processed.

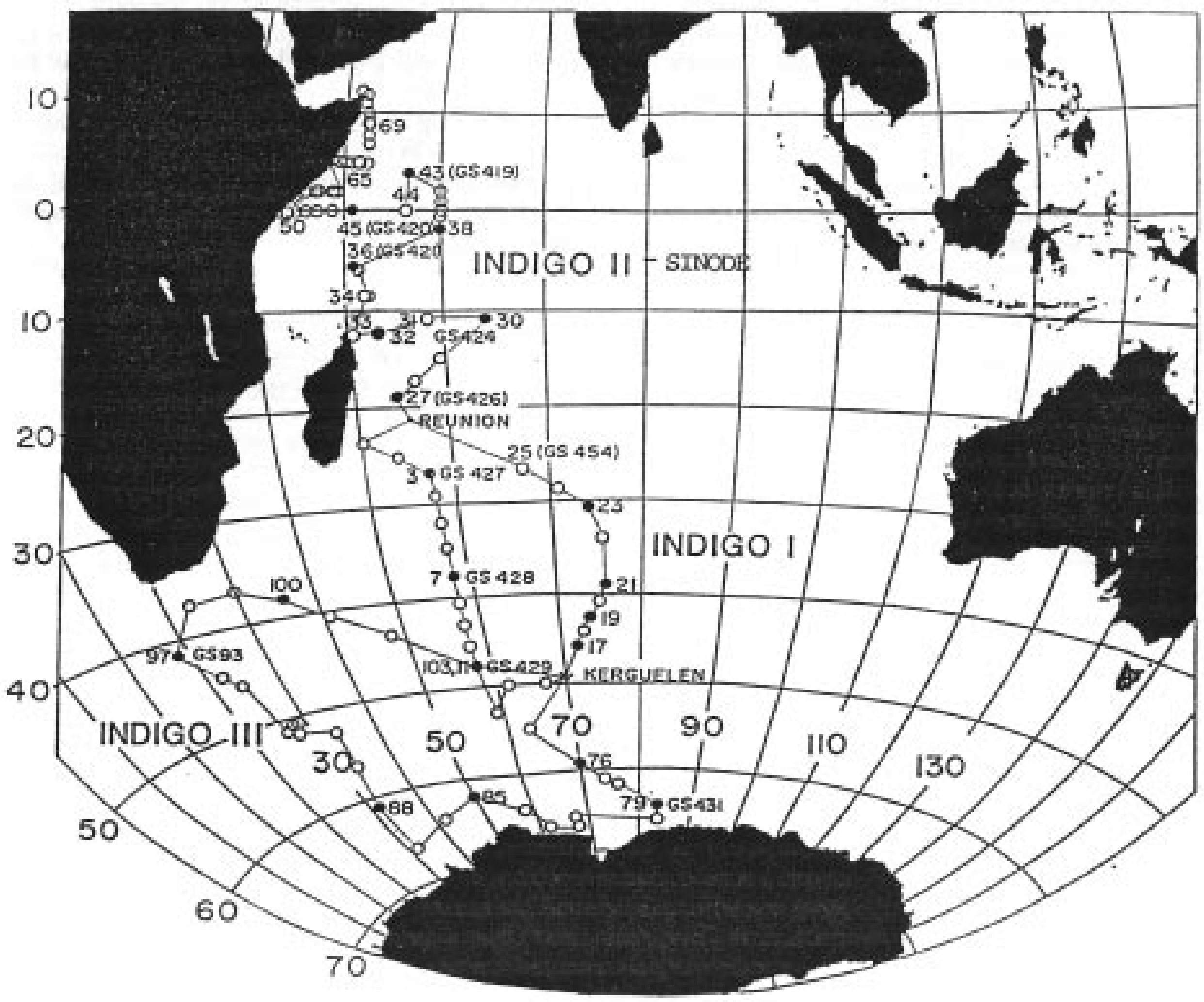

Figure INDIGO expeditions I (1985), II (1986), III (1987): o - small volume samples: • - small and large volume samples: GS - re-occupied GEOSECS stations.

The data still require thorough interpretation. However, INDIGO provided the first freon data set in the area and this shows evidence for transient invasion along the isopycnals of the subtropical gyre and in the intermediate waters, and for deep water formation along the Antarctic coast. Compared to GEOSECS, invasion of bomb-produced ^{14}C had progressed northward and with depth and a comparison of the column inventories of excess ^{14}C demonstrates a concentration in low latitudes. ^{14}C was much better sampled during INDIGO than during GEOSECS thanks to the denser coverage, and to the use of the mass spectrometric technique. In deep waters, ^{3}He excesses show intermediate values between the Atlantic and the Pacific values, and help constrain the intensity of hydrothermal input. Along the equator, nutrient and freon data strongly suggest cross-isopycnal upwelling off the African coast. Thus INDIGO provided another example of how chemical tracers help the visualization of the ocean circulation. Clearly, however, the sampling is inadequate for a basin-scale description, in particular, access to some coastal waters was not possible: the central and eastern parts of the basin as well as the Mozambique Channel should be sampled during WOCE. The use of the transient tracer information requires repeated surveys: the areas sampled by INDIGO should be revisited in 10 years' time.

For more information concerning INDIGO and its Atlas, write to A. Poisson, LPCM, UPMC, 4 Place Jussieu, 75230 Paris Cedex 05, France.

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Reference

Poisson, A, Schauer, B, Brunet, C. 1988. Les rapports des campagnes a la mer a bord du “Marion Dufresne”. MD43/INDIGO I, TAAF, 85-06, 267pp.

The WOCE Chinese Workshop with Emphasis on the Western Pacific, Qindao, China, 6-7 April 1988

As part of the process of discussing the WOCE Programme and seeking widespread participation a meeting with Chinese oceanographers was held at the Academia Sinica Institute of Oceanology at Qindao. Local arrangements were made by an organizing committee chaired by Professor D.X. Hu. Chinese participants included scientists from institutes of both the Academia Sinica and the State Oceanographic Administration as well as Universities. The international WOCE party was composed of J-F. Minster, G. Needler, Y. Nagata, W.D. Nowlin, L. Talley and J. Willebrand.

Talks were presented covering the overall organization and objectives of WOCE, satellite measurements, the WHP, tracers, etc. with, where possible, an emphasis of the particular problems facing WOCE in the Western Pacific. Several talks were then presented by Chinese scientists on their present work and long-term programmes in the region.

The latter part of the meeting was spent discussing possible Chinese participation in WOCE and ways that preparations for such participation could be developed. Attention was focussed on the Hydrographic Programme, especially concerning repeat hydrography; satellite measurements; modelling; sea-level measurements and the Voluntary Ship Programme. A report of the meeting has been prepared and distributed. Copies are available from the WOCE-IPO.

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SEA LEVEL MEASUREMENTS IN HOSTILE REGIONS

Experts from 10 Countries with experience in high-latitude sea level measurement met at the Proudman Oceanographic Laboratory, Bidston, UK (which hosts the Permanent Service for Mean Sea Level) in March 1988 to discuss the feasibility of establishing a network of stations in southern waters along the Antarctic coast and on islands. The experts were from the UK, FRG, France, USA, Canada, South Africa, Denmark, Norway, Japan and Australia. The principle conclusions of the meeting were:

(1) Technology exists and is affordable to make sea level measurements in hostile regions,

(2) Technology and techniques must be site specific,

(3) Bench mark connections are mandatory at the applicable state of the art,

(4) Atmospheric pressure measurements are mandatory at the applicable state of the art,

(5) Real time data transmission is required to ensure proper operation and early availability of data to the user community,

(6) Since the availability of global reference systems has increased (VLBI/GPS), local reference systems can be tied into the global systems to improve the quality of the sea level measurements,

(7) Bench marks themselves have to meet technical requirements for the site in view of permafrost disturbances and other local hazards.

Several existing stations and developmental activities being undertaken were described. Following are three examples which demonstrate the diversity of approaches and the potential for success if resources are available and regular maintenance is possible - the Japanese Syowa station (69°00’28"S, 39°34’13"E), the UK study at Tristan da Cunha and the Canadian Cornwallis Is station.

Syowa station has been in operation since 1966 at which time 10 stable bench marks were set in rock. A strain gauge was installed in 1975 and a second was installed in 1981 (simultaneous operation until 1985). The latter is still in operation 20 m from a quartz oscillator (Japanese make) installed in 1987. A second quartz oscillator installation is planned for 1988. The data for the site reside with the Institute of Antarctic Research which is preparing a time series of these data starting with 1966. Japan is considering transmission of the data via satellite (INMARSAT) but has no plans for VLBI.

The Tristan da Cunha study by the Proudman Oceanographic Laboratory is investigating the differences between harbour and off-shore measurements in high energy regions. Three bottom pressure gauges have been placed approximately 100 miles off shore at 3-4000 m and a fourth gauge is in the surf zone. A preliminary conclusion is that the surf zone gauge would not be adequate for WOCE purposes.

The Cornwallis station is part of the Canadian permanent programme. A pragmatic approach is taken, so it is an on-the-shelf installation, with the site dictating the specific arrangement and is, unfortunately, expensive - approximately Can $100,000 at Cornwallis, a mining company site. The gas purge system at Cornwallis is connected to a brass orifice which is located in a protected, temperature-controlled hut. There are 5 bench marks in a local net but they are not attached to the national net. Data collected by the gauge are transmitted by satellite. This system has been operating successfully for about two years. Further developments will include adapting the gauge for operation in areas without a vertical structure and improving the bottom-mounted pressure gauging technique for long-term operation by incorporating an arctic barometer and investigating electromagnetic techniques (through rock) for data transmission.

The report of the meeting containing descriptions of the on-going and past experiences of all the countries and their recommendations is being published in the IOC Technical Series.

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JAPAN-US COLLABORATION ON WOCE

Seminar: Seattle, 8-12 June 1987

A Japan-US Seminar on the World Ocean Circulation Experiment (WOCE) was convened by Drs Yutaka Nagata and Worth Nowlin on 8-12 June 1987 at the Applied Physics Laboratory of the University of Washington in Seattle. The seminar reviewed progress made since the First Workshop on Joint Japan-US WOCE Efforts, held in March 1986 in Tokyo, and then addressed a broad series of immediate issues.

It was recognized that measurement programmes now underway or planned are likely to provide a good pre-WOCE reconnaissance of deep western North Pacific boundary currents. These programmes include Japanese studies in the North Pacific Basin, along the Izu-Ogasawara Ridge, and on the continental margin near 36°N; US efforts south of the Aleutians along 175°W, and from the Hokkaido continental margin across the Kuril-Kamchatka Ridge; and a two-year Canadian-US field study of the Alaskan Gyre near Ocean Station P.

A direct study of heat and fresh water transport in the North Pacific will be essential for WOCE Core Project 1 and would also better define temporal and spatial variations in the Kuroshio (e.g., meander versus non-meander phases and interactions between the Kuroshio and warm eddies offshore near the Izu Ridge). Such a programme should include a series of transects: in Tokara Strait; to the south of Honshu (off Cape Toimisaki and/or off the cape of Shionomisaki); along the Izu-Ogasawara Ridge; east of Taiwan near 24°N; and in the East China Sea and the Pacific across the Ryukyu Islands.

Separate studies of the structure and dynamics of the Philippine Sea, including those planned by Japanese scientists, are needed to address dynamics of deep circulation and water mass formation and transport. In particular, a series of direct current measurements by Japanese scientists using moored current meters and CTD observations already underway may be extended in 1989.

It was recognized that a study of the subpolar gyre in the North Pacific should be an important component of WOCE. Such a study should detail the structure of the gyre and determine its variability, thus providing a data base for modelling studies as well. The study should focus on intermediate water formation and convection in the North Pacific. Processes active in the eastern Pacific boundary region would he compared and contrasted with those in the Oyashio-Kuroshio boundary region in the Western Pacific.

It was also agreed that the draft WOCE Hydrographic Plan should be modified to provide denser station coverage in the western Pacific and to add five long meridional sections through the North and South Pacific near 165°E, 175°W, 150°W, 130°W, and 95°W. Meridional sections which cross the subpolar gyre are essential for measuring the predominantly zonal flow. Since intensive measurements are now being made at 165°E, 140°W, and 110°W in the tropics as part of TOGA, it was suggested that current WOCE plans for meridional sections be altered to take advantage of these measurements.

The excellent sampling by the Japanese in the Western North Pacific including the Kuroshio should continue during WOCE. The four long meridional sections in the Western Pacific presently being occupied (at 130°E, 137°E, 144°E and 155°E), have also been identified as being important to WOCE. They should be occupied once with full small-volume sampling to the ocean bottom. It was concluded that sections in the northeast Pacific might best be carried out by US and Canadian vessels. Additionally, repeated XBT sampling using ships of opportunity will be needed along sections between Japan and Hawaii; through the northern North Pacific; along Japanese supply ship tracks to Antarctica; and along tanker tracks from Alaska to Cape Horn.

Numerical modelling studies of circulation dynamics might address: water mass formation; formation of the mixed water region between the subpolar and subtropical gyres in the western North Pacific; subpolar gyre models using climatological windstress data; bi-modal paths of the Kuroshio south of Japan; the eastern subtropical gyre; the effect of the Hawaiian ridge on subtropical circulation; and bifurcation of eastward flow in the eastern North Pacific.

It was evident that global programmes for investigation of the surface layer and computations of air-sea fluxes will call for intensive modelling-observational studies of the Kuroshio and Oyashio, including a comprehensive study of wind forcing over the North Pacific subtropical gyre. It was suggested that the path of the Kuroshio might be forecast using a combination of NSCAT winds from the Pacific, global WOCE wind-stress products, and altimetric measurements of the Kuroshio.

Both Japan and the US will conduct satellite missions to acquire data crucial for determination of global surface fluxes. Japan's first Marine Observation Satellite (MOS-1) is presently operational. It carries three radiometers and is in a 17-day repeat polar orbit at 909 km altitude. A second similar satellite, MOS-1(b), is ready for launch in the event of failure or degradation of MOS-1. The data from these missions will complement and supplement measurements obtained from US NOAA orbiters, DMSP/SSMI, and NROSS (when launched). MOS-1 (and MOS-1(b)) significantly overlap on-orbit with NOAA AVHRR and DMSP SSM/I instruments. JERS-1 and NROSS may also overlap. Because of this complementarity, on-orbit cross-calibration and comparison analyses should be performed.

To derive optimal use of satellite data and resulting products and to facilitate planning of WOCE in situ measurement programmes, it was recommended that the International Scientific Steering Group for WOCE establish a committee on satellite products. This committee could serve as a forum and information resource for: identifying available products; serving as a clearinghouse for technical information and project contact points; coordinating joint calibration and comparison studies; characterizing accuracies of products; recommending changes in algorithms and analysis schemes used in data reduction and in preparation of products; addressing international data exchange issues; and suggesting data formats and contents. New technology needed for WOCE is actively being developed in both countries. In Japan technology development efforts include current meters and releases for operation to 12,000 metres; acoustic Doppler current profilers; surface drifters; inverted echo sounders for use in depths to 6000 metres; and drifting wave recorders. US activities are addressing tracer injector technology; water samplers; fast fish; RAFOS and pop-up floats; accelerator mass spectrometry; freon measurement technology; and automatic XBT launchers.

Japanese and US scientists will also address issues related to use of surface drifting buoys. These will include drogue configurations and water-mass following characteristics; supplementary sensors such as those for SST, subsurface temperatures and pressures, and sea level pressure; and more efficient and less expensive arrangements for use of the ARGOS system to meet the expected increased needs for transmitters in WOCE.

It was agreed that US and Japanese scientists should arrange for expeditious exchange of operational in situ buoy data (for calibration purposes), as well as satellite data. It was concluded that tests should be made to determine how well satellite data alone are adequate for determining air-sea surface fluxes.

(Printed copies of documents prepared for and distributed at the seminar may be obtained from the US WOCE Planning Office, Department of Oceanography, Texas A&M University, College Station, Texas 77843, USA, or from Dr Yutaka Nagata, Geophysical Institute, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan).

Informal Meeting: Tokyo, 2 April 1988

Members of the US and Japanese WOCE Scientific Steering Committees met at the Japan Meteorological Agency in Tokyo on 2 April 1988.

A number of on-going Japanese activities related to WOCE and suggestions for their possible expansion were introduced. These included details of sampling carried out by operational service organizations such as the Japan Meteorological Agency and the Hydrographic Department of the Maritime Safety Agency, and preliminary results from the ‘Deep Water Circulation Experiment’ project being undertaken by Japanese university groups.

An overview of the US-WOCE Implementation Plan and the proposed time schedule of US-WOCE actions were presented.

The status of the satellite scatterometer programme was discussed, and its importance for WOCE studies was emphasized by both US and Japanese scientists. It was decided that the US and Japan WOCE SSGs jointly send a letter to NASDA in support of a NASA proposal to include the scatterometer NSCAT aboard the Japanese satellite ADEOS.

Future Seminar

At both the above venues it was agreed that Japan-US co-operation in WOCE is essential especially in the Pacific area. Consequently a third Japan-US seminar is needed to set bilateral plans in motion. This is scheduled to be held in Japan in June 1989 and will take into account the results of the International WOCE Scientific Conference to be held in November 1988. Representatives from other North Pacific countries may be invited.

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THE 2ND WOCE WORKSHOP IN SOUTH AMERICA

A “Workshop on Ocean Dynamics and Climate in South America” took place at the Centro de Investigaciòn para la Dynàmica del Mar y la Atmòsfera, CIMA, Buenos Aires, Argentina from 18 to 22 July 1988. It was hosted by the director, Dr Isidoro Orlanski and attended by scientists from Argentina (23), Brazil (3), Chile (3), Peru (1) and Uruguay (2) besides Dr F Robles for IOCARIBE/I0C and Dr K P Koltermann from WOCE-IPO.

The workshop was organized by IOC in conjunction with Argentinian authorities and the IPO. It was split into a two-day discussion and presentation on IOC programmes and services related to climate problems, chaired by Fernando Robles, and a three-day discussion on possibilities of South American participation in and contribution to WOCE, chaired by Isidoro Orlanski. The WOCE Implementation Plan was distributed as an advance copy to the participants. A report on the meeting is available in Spanish.

The IOC presentation mainly focussed on the programmes IODE, IGOSS, GLOSS and TEMA and included summaries of on-going and planned national activities. In all these national programmes for both field and model studies special emphasis is laid on the continental shelf and shelf slope. Little chance is seen for basin-scale work although Brazilian work on the south-equatorial bi-furcation, the North Brazil Current and the Chilean interest in the West-wind Drift bi-furcation are of relevance.

During the WOCE workshop the participants identified themselves with items specified in the WOCE Implementation Plan and used its figures and tables in their discussion. They expressed their great interest in it to the degree of resources available to them. The subsequent discussion dealt with the following topics:

- There is a broad acceptance that detailed discussion and co-ordination on oceanographic research programmes in South America is needed on a regular basis, incorporating more actively scientists in this process. Different mechanisms were aired and a ‘Conference of South American Oceanographers’ was seen as a solution.

- In South America all identified WOCE-related programme items concentrate on continental slope and coastal areas. Working in the deep ocean is limited by lack of appropriate resources. Strong interest exists in Argentina in co-operating with WOCE programmes for deep moorings and the repeat hydrography sections AR8. All countries expressed interest in getting more involved in running or maintaining VOS lines although resources in terms of XBT probes etc. are restricting involvement at present. For float deployment, repeat hydrography and mooring re-deployment local support in the form of ships seems to be available.

- There was general consent that co-operative WOCE efforts involving laboratories from different countries should be supported to enhance available techniques and expertise, adapt new technologies and further increase the quality of the personnel involved. For field operations it was agreed that a ‘local lab’ should get involved in serving as a base for logistics, communications and storage of equipment. It was also felt that this local knowledge should be used to facilitate administrative matters as customs procedures, clearances etc.

- In general there was consensus that a mixed representation of scientists and ’funding agency representatives’ for countries present at the Paris Conference would be best. The workshop served to prepare the community for the conference and highlighted several aspects that allow focussing on how to approach a participation in WOCE.

- The recommendations of the workshop call on the nations present and others in South America.
  - to establish National Committees for the WCRP components TOGA and WOCE,
  - elaborate national scientific programmes for WOCE and TOGA,
  - focus on WOCE components of immediate interest to South American countries,
  - promote the co-operation in these areas and topics,
  - facilitate the implementation and maintenance of the necessary scientific infrastructure and the human resources needed for these programmes,
  - ascertain an active participation at the WOCE Scientific Conference through relevant scientific representation and concrete information on national contributions to the global programmes.

They also called on IOC, WMO and other relevant international organizations to fund and facilitate the interaction between the nations in order to pursue above objectives.

The entire meeting was conducted in an extremely business-like and co-operative atmosphere, supported by the constant friendly assistance of the local staff.

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WOCE SURFACE VELOCITY PROGRAMME MEETING

25-26 April 1988, AOML, Miami, USA

The workshop, convened by Peter Niiler (SIO) as the chairman of the SVP Planning Committee, focussed on how to translate the general WOCE needs for a global surface velocity data set and some other regional applications into a coherent programme and to propose a structure of how to do it. Drawing on the expertise acquired in running similar programmes in TOGA the agenda and the participants were asked to cover these aspects. It was attended by participants from the USA (15), Japan (1), Argentina (1), FRG (1), France (2), Australia (1), Canada (2), Brazil (1) and the WOCE International Planning Office.

Individuals presentations covered special data sets and their interpretation and the use of surface drifters for process studies.

Don Olson showed his most recent results from the South Atlantic, Bill Large used the FGGE data set to demonstrate the problem of using air pressure fields from an undersampled region such as the South Atlantic for the interpretation and Don Hansen presented the Pan Pacific Surface Current Study using an extended TOGA data set. Andrew Bennett looked into statistical questions and proposed a cluster deployment to enhance the significance of the data set.

Harua Ishii summarized drifter deployments around Japan and some Japanese technological developments. George Cresswell reported on Australian activities and plans, as did Walter Zenk on recent German work in the North Atlantic and plans for the South Atlantic.

Numerous technical and logistical details were discussed. One imminent problem concerned the proposed transmission of ARGOS drifter data on the GTS, with which some participants raised strong objections. It also became apparent that at one time or other each major ocean basin had been subject to an extensive drifter study. It thus emerged that these data sets should be worked up and made available to future collaborators in WOCE. Technical and financial implications of the WOCE programme on ARGOS were discussed with Archie Shaw from Service ARGOS. The present number of ca. 670 platforms/year will rise during WOCE by a factor of 4 to 5, not accounting for other uses of the ARGOS system during WOCE.

Further discussion focussed on data assembly and archiving and possible products. It was felt that the existing RNODC for Drifting Buoys at MEDS, Ottawa should serve as the quick-reference data centre for all drifter data. For that purpose all drifter data should be put on the GTS by Service Argos. In a delayed mode, the final data would be made available to the data centre by Service Argos through the respective PIs. This data centre will, following the general WOCE philosophy regarding such matters, be working back to back with a research group actively involved in the evaluation of drifter data. It was also stressed that the WOCE community expects global or basin-wide velocity fields, and that these products should have a high priority, not withstanding the needs or interests of the individuals PIs and the requirement to collect the full-length time-series.

Finally, the workshop agreed that WMO should be approached through the relevant bodies to ensure that existing and future meteorological drifter programmes use buoys equipped with drogues to make best use of these platforms from an oceanographic point. In exchange one might arrange to equip the proposed WOCE drifters with sensors for sea-surface temperature and air pressure.

A report of the meeting is in preparation and will be made available by the WOCE International Planning Office, Wormley.

K.P. Koltermann
WOCE International Planning Office
Wormley, Godalming, Surrey, UK

INTERNATIONAL WOCE SCIENTIFIC CONFERENCE PROGRAMME
(Unesco Headquarters, Paris, 28 November - 2 December 1988)

Chairman: G. Siedler

28 November

10:00-10:45	Opening	G. Siedler
	Addresses by Agency Heads UNESCO, WMO, ICSU, IOC and SCOR	
10:45-11:15	Keynote Address	R. Stewart
11:15-11:45	COFFEE	
11:45-12:00	Organization of the Conference	G. Siedler
12:00-12:20	Introduction of the WOCE Implementation Plan	G. Needler
12:20-12:30	A WOCE Perspective	A. McEwan
12:30-14:30	LUNCH	

THE WOCE SCIENTIFIC PROGRAMME (Chaired by C. Wunsch)

14:30-14:55	WOCE Objectives and Overview	C. Wunsch
14:55-15:20	CORE Project 1, The Global Description	L. Talley
15:20-15:45	CORE Project 2, The Southern Ocean	A. Gordon
15:45-16:15	COFFEE	
16:15-16:40	CORE Project 3, The Gyre Dynamics Experiment	J. McWilliams
16:40-15:05	WOCE Modelling	J. Willebrand
17:05-17:25	Atmospheric Forcing	K. Hasselmann
17:25	Review of the Day	G. Siedler

29 November

OBSERVING AND DATA MANAGEMENT SYSTEMS
(Chaired by J Woods)

09:00-09:10	Summary of Requirements	J. Woods
09:10-09:35	WOCE Hydrographic Programme	T. Joyce
09:35-09:55	Satellite Systems	M. Lefebvre
09:55-10:15	Subsurface Floats	R. Davis
10:15-10:35	Surface Drifters	P. Niiler
10:35-11:00	COFFEE	
11:00-11:25	Moorings	R. Dickson
11:25-11:45	In-Situ Sea Level Measurements	P. Koltermann
11:45-12:15	Data Management System	J. Crease
12:15-12:30	Review of the Morning	G. Siedler
12:30-14:30	LUNCH	
14:30-15:00	Voluntary Observing Ships Oceanographic Requirements Meteorological Requirements	 Y. Tourre P. Taylor

29 November

RESOURCE ASSESSMENT AND PROGRAMME COORDINATION

15:00-17:30	National Statements (Chaired by A. McEwan)	
15:45	COFFEE	

30 November

9:00-12:15	National Statements (Chaired by P. Morel)	
10:45	COFFEE	
12:15-12:30	Organization of Conference Working Groups	G. Siedler
12:30-14:30	LUNCH	
14:30-17:30	Working Group Sessions	
15:45	COFFEE	

1 December

9:00-10:30	WOCE Organizational Arrangements	G. Siedler
10:30-11:00	COFFEE	
11:00-12:30	Working Group Sessions	
12:30-14:30	LUNCH	
14:30-17:30	Working Group Reports, Assessment of Available Resources and Unfilled Requirements	G. Siedler
15:45	COFFEE	

2 December

CONCLUSIONS AND REQUIRED ACTIONS

10:00	Recommendations of Conference	G. Siedler
10:30-13:00	Summary, Conclusions and Next Steps	D.J. Baker
11:30	COFFEE	
13:00	Closing	G. Siedler

WOCE is a component of the World Climate Research Programme (WCRP), which was established by WMO and ICSU, and is carried out in association with IOC and SCOR. The scientific planning and development of WOCE is under the guidance of the JSC/CCCO Scientific Steering Group for WOCE, assisted by the International WOCE Planning Office. JSC and CCCO are the main bodies of WMO-ICSU and IOC-SCOR, respectively for formulating overall WCRP scientific concepts.

The WOCE Newsletter is edited at the WOCE-IPO at IOS, Wormley, Godalming, Surrey, UK by Denise Smythe-Wright. Financial support is provided by the Natural Environment Research Council, UK

Contributions should not be cited without the agreement of the author.

We hope that colleagues will see this Newsletter as a means of reporting work in progress related to the Goals of WOCE as described in the Scientific Plan. The SSG will use it also to report progress of working groups, and of experiment design and of models.

The editor will be pleased to send copies of the Newsletter to Institutes and Research Scientists with an interest in WOCE or related research.